A LAYMAN'S NOTES ON THE HURRICANE TIDE AT MIAMI

By W. J. SCHUBERT

[Miami, Fla., March 8, 1927]

In the MONTHLY WEATHER REVIEW I read an article [1] several years ago on hurricane tides in which, as I recall it, the following facts were set forth:

The hurricane tide has no connection with moon or sun. It is driven up by the winds in the right-hand rear quadrant of the storm which are the most violent of all. It reaches its highest crest close to the right-hand side of the line of the storm's advance and extends outward for considerable distances, but tapers off very quickly on the left-hand side of the line of the storm's advance. The crest of the storm tide has reached heights of as much as 18 feet.

To these I would add the following, based on observations made at Miami Beach during the September 18 hurricane:

The hurricane tide wave is much more abrupt than normal tides. It precedes the storm center. The highest crest of the storm tide occurs a little more than an hour before arrival of the storm center. Lowest water occurs with the arrival of the storm center.

Data on which these observations are based are as follows:

I was in an ocean-front apartment at Miami Beach throughout the storm. There is a 30-foot street in front of the apartment (Ocean Drive), beyond which is a park approximately 100 feet wide, and beyond this is the beach, varying from 125 to 200 feet wide according to formation and tide.

At midnight I visited the beach. Wind was coming from almost due north, which made it parallel to or slightly off shore. There was little surf, the waves being less than 18 inches high. The wind had not reached gale proportions. The eastern sky was heavily overcast, but in the west it was clear and comparatively bright (the moon was nearly full) and stars clearly visible. The tide was normal.

At 2 o'clock a. m. I again visited the beach. The wind had increased rapidly meantime and had now reached destructive force, making it necessary to crawl, as walking was impossible. Trees were breaking and falling, visibility was practically nil (less than 20 feet), and the air was filled with sheets of horizontally driven salt spray. The roar of the storm was appalling. I found the water's edge showing normal tide and little surf.

After this time the wind reached such violence that it was impossible to again visit the beach until arrival of the storm's center.

The salt spray had filled the street level full and had also filled all low spots; but at 3:50 a. m. I noted a definite rise in the water over a sidewalk on the south side of the building, and by 4:30 a. m. salt water was 23 inches above the sidewalk. At 4:10 a. m. I heard a muffled thud, saw water spurt in around the front door, and, going to the side door, saw a breaker, perhaps 18 inches high, crested with broken water, roll past and disappear in the darkness inland. After this the breakers came regularly and continuously until 4:50 a. m. when they disappeared. Their greatest height was perhaps 24 inches about 4:30 a. m. I also found a big Gulf Stream jellyfish just outside the door on the sidewalk in the water at 4:25 a. m.

After 4:30 a. m. the water receded slowly at first, then faster, and at 5:05 water had disappeared excepting for puddles in the low spots.

During this time the wind continued with extreme and constantly increasing violence from very nearly north.

Daylight now began to filter through, and at 6:05 a. m. the wind suddenly fell to a light air and rapidly shifted to southeast by south. The air cleared and visibility increased to perhaps 3 miles.

I at once visited the beach. I found the water at least a foot below normal low water—the lowest I have ever seen it. A tremendous surf was now pounding in from the southeast. At 6:40 a. m. a dark squall drove swiftly in from the southeast, and in 10 minutes the wind had reached greater violence than before.

I presume the tremendous force of the wind, which was now diagonally on shore, again piled the water up ahead of it to some extent and that there was another rise in the tide on the beach. Violence of the wind, however, utterly precluded any attempt to confirm this, and the air was so filled with spray that the ocean was entirely invisible.

As nearly as I can determine, therefore, the storm tide rose between 9 and 10 feet in the two and one-half hours between 2 o'clock a. m. and 4:30 o'clock a. m. It fell between 10 and 11 feet in the hour and a quarter between 4:45 and 6 o'clock a. m. It reached its highest point an hour and twenty minutes before arrival of the storm center and its lowest point when the storm center arrived.

My position was evidently in the northern (or right-hand) edge of the storm center. The sky never entirely cleared and I did not see the sun, but both clear sky and sunshine occurred 4 miles farther south during passage of the center.

Proximity of the Bahama Banks, some 45 miles east of Miami Beach, probably prevented the winds from driving up such a high storm tide as occurred at Galveston. This fact, together with the fact that the wind was slightly off shore prior to arrival of the storm center, was probably the salvation of Miami Beach.

The figures and time mentioned here do not coincide exactly with observations made along the water-front in the bay; but it is my opinion that in the bay local conditions, such as the shape of the bay, the inability of tidal waters to get in and out quickly, and other factors, had some effect.

Other phenomena I noted were:

Hurricane winds, or at least the clouds, mist, and spray, that accompany these storms, must be rather shallow. For after the sun rose, even when the storm was at its height, there was almost sufficient light to throw shadows. At the same time the air was so filled with horizontally driven salt spray, mist, and rain that houses 300 feet distant were entirely invisible and those 200 feet away could be seen only faintly.

The barometer, which reached its extreme low of 27.61 about 6 o'clock a. m., rose so rapidly when the storm center arrived that movement of the hand was actually visible. In the first few minutes it rose above 29. Of course it again quickly fell to nearly its former low when

[1] Monthly Weather Review 48: 127-145.

the center passed. This change in atmospheric pressure was not noted nor mentioned by any of the occupants of the apartment. All, however, complained of the heat, especially during the earlier hours of the storm.

After the storm I found a live grouper, weighing perhaps 60 pounds, in a puddle three blocks back from the ocean. I also saw several fish, principally grouper, half buried in the sand that covered the Ocean Drive. I counted the following day above 300 dead fish on the beach in a distance of a quarter of a mile. Nearly all were bottom fish—groupers, snapper, sailor's choice, grunts, progies, sheepshead, toadfish, etc. Of the surface swimmers I saw perhaps a dozen mullet, but the halfbeaks (or ballyhoo), the needlefish, etc., were entirely absent.

The great majority of these fish had evidently washed ashore after the main storm had passed, as they lay down at the edge of the water where a small surf had left them. The heavy seas I saw breaking during the storm center had gone far higher.

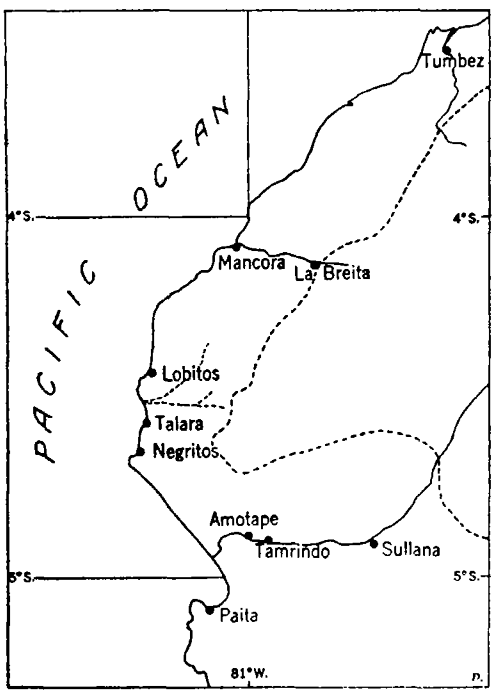
METEOROLOGICAL OBSERVATIONS AT NEGRITOS, PERU, DECEMBER, 1924, TO MAY, 1925

By E. WILLARD BERRY

[Dated Negritos, Peru, June 15, 1926]

The desert of northwestern Peru, better known locally as the Desert de Tumbez, is the center of the oil fields of Peru. In this northwestern region are located the fields of the International Petroleum Co. (Ltd.) of Canada, the Lobitas Co., and the Zorritos Co. Very little has been written of its climate, and of late years, its floods.

The Northwestern Desert of Peru is an area extending from Rio Tumbez on the north to Rio Chira on the south, in all about 140 miles long, and from the sea on the west to about the crest of the coastal mountain ranges on the east, roughly 50 miles wide. This desert under normal conditions is one of the driest in the world. There is, during normal years no measurable rainfall. Along the coast a little mist collects on roofs and drips off, but this is all. Yet rains actually do occur here. The proximate reason for their occurrence seems to be the weakening or shifting of the Humboldt or Peruvian Current. The west coast of South America is washed by this cold current and by more or less upwelling of deep water along the coast due to the earth's rotation. The Humboldt Current runs northward at such a rate as to be appreciable in coastwise shipping. It flows along the coast as far north as the region of Cabo Blanco, where it is met by the warm Ecuadorian Current and turned westward to form the Pacific South Equatorial Current. The first of these, being cold, maintains a relatively low temperature in the air over it, so that when this air blows toward the land our temperatures are several degrees lower than they would otherwise be. The capacity of this air for water vapor is not high. Hence, even though the water vapor in it may be nearly or quite at the saturation point when the winds arrive over the hot land, they are soon raised to a temperature far above that of saturation, so they absorb quickly any moisture available on the land, causing desert conditions.



Now when, for any reason, the northward flow of this cold Humboldt Current is interrupted or pushed further from the coast the warm Ecuadorian Current usurps its path and invades the coastal waters from the north. This usurping current is called El Niño, the Little One. It raises our land temperatures and also allows the winds to carry more moisture. When the winds thus enriched strike the land they are chilled, especially by the sudden radiation from the land after sunset, and the saturation point being lowered, rain occurs. This is what appears to have happened in 1925 and 1926.[1] There are references to other floods in 1856 and later in 1891.

Speed of El Niño.—On March 6, 1926, when the sea temperature at 12 o'clock was 90°, I noticed at about noon several large masses of drift in the sea. Such masses are uncommon, hence very noticeable. The night before had been rainy and the bridge at Quebrado Parinias, which is at least 15 miles to the north, had washed away. Of the 15 miles, 6 are in the quebrado and the other 8 are in open sea. The bridge went sometime during the night of March 5 and the drift beached about 1 p. m. on March 6. It had taken not more than 15 hours to make the 15 miles. A mass of drift that I timed made 4,000 feet in 50 minutes, or about 4,800 feet an hour. I believe this estimate to be nearly correct, as the material would travel faster in the quebrada than in the open sea. This is only one example of the way the currents went south this year. I have also picked up mangrove seeds on the beach. As far as I can ascertain there are none growing to the south and the nearest to

[1] It seems not likely that chilling of the warm, wet wind by contact with a radiation-cooled land surface could be more than a very minor cause of the precipitation described. The only air to be largely affected by such cooling is the thin surface stratum through which the very slow process of conduction could work, the stratum being only a very few feet thick even under the most favorable conditions of great calm. Turbulent mixing of this thin skin of cooled air with air not so cooled, above, would promptly reduce the effectiveness of the cooled air as a rainmaker. One must look for action on a far grander scale than this as the cause of the downpour described by the author.

Only violent convection can cause violent rain. There must have been present in the situation discussed at least two causes of violent convection: (1) The forced rising of warm and heavily moisture-laden air against the highland barrier; (2) the recognized tendency at sea, especially in warm latitudes, to the occurrence of nocturnal showers even in the absence of an obstructing land. These showers are the result of strong convection induced by nocturnal cooling aloft so greatly in excess of the restrained cooling at the sea surface that the resulting superadiatic lapse rate causes convectional overturning. Now, nocturnal showers over this coastal land were one of the characteristics of the rains described later in the present paper. The moisture for them may well have been brought inland from the sea, either as showers already in process (in which case they would be strongly augmented by forced rising against the highland) or as a vast supply not yet released by convection over the sea, but only awaiting the very effective trigger action of the forced rising to let loose the fierce cloudbursts described.—*B. M. V.*